

Description

[CORING TOOL WITH RETENTION DEVICE]

BACKGROUND OF INVENTION

[0001] Wells are generally drilled into the ground to recover natural deposits of oil and gas, as well as other desirable materials, that are trapped in geological formations in the Earth's crust. A well is drilled into the ground and directed to the targeted geological location from a drilling rig at the Earth's surface.

[0002] Once a formation of interest is reached, drillers often investigate the formation and its contents by taking samples of the formation rock and analyzing the rock samples. Typically, a sample is cored from the formation using a hollow coring bit, and the sample obtained using this method is generally referred to as a "core sample." Once the core sample has been transported to the surface, it may be analyzed to assess, among other things, the reservoir storage capacity (porosity) and the flow potential

(permeability) of the material that makes up the formation; the chemical and mineral composition of the fluids and mineral deposits contained in the pores of the formation; and the irreducible water content of the formation material. The information obtained from analysis of a sample is used to design and implement well completion and production facilities.

[0003] "Conventional coring," or axial coring, involves taking a core sample from the bottom of the well. Typically, this is done after the drill string has been removed, or "tripped," from the wellbore, and a rotary coring bit with a hollow interior for receiving the core sample is lowered into the well on the end of a drill string. Some drill bits include a coring bit near the center of the drill bit, and a core sample may be taken without having to trip the drill string. A core sample obtained in conventional coring is taken along the path of the wellbore; that is, the core is taken along the axis of the borehole from the rock below the drill bit.

[0004] A typical axial core is 4–6 inches (~10–15 cm) in diameter and can be over 100 feet (~30m) long. The rotary motion is typically generated at the surface, and the coring bit is driven into the formation by the weight of the drill string

that extends back to the surface. The core sample is broken away from the formation by simply pulling upward on the coring bit that contains the sample.

[0005] By contrast, in "sidewall coring," a core sample is taken from the side wall of a drilled borehole. Sidewall coring is typically performed after the drill string has been removed from the borehole. A wireline coring tool that includes a coring bit is lowered into the borehole, and a small core sample is taken from the sidewall of the borehole.

[0006] In sidewall coring, the drill string cannot be used to rotate the coring bit, nor can it provide the weight required to drive the bit into the formation. Instead, the coring tool must generate both the rotary motion of the coring bit and the axial force necessary to drive the coring bit into the formation.

[0007] In sidewall coring, the available space is limited by the diameter of the borehole. There must be enough space to withdraw and store a sample. Because of this, a typical sidewall core sample is about 1 inch (~2.5 cm) in diameter and less than about 2 inches long (~5 cm). The small size of the sample does not permit enough frictional forces between the coring bit and the core sample for the core sample to be removed by simply withdrawing the coring

bit. Instead, the coring bit is typically tilted to cause the core sample to fracture and break away from the formation.

[0008] An additional problem that may be encountered is that because of the short length of a side wall core sample, it may be difficult to retain the core sample in the coring bit. Thus, a coring bit may also include mechanisms to retain a core sample in the coring bit even after the sample has been fractured or broken from the formation.

[0009] Sidewall coring is beneficial in wells where the exact depth of the target zone is not well known. Well logging tools, including coring tools, can be lowered into the borehole to evaluate the formations through which the borehole passes. Multiple core samples may be taken at different depths in the borehole so that information may be gained about formations at different depths.

[0010] FIG. 1 shows an example of an existing sidewall coring tool 101 that is suspended in a borehole 113 by a wireline 107, as disclosed in U.S. Patent No. 6,412,575, which is assigned to the assignee of the present invention. A sample may be taken using a coring bit 103 that is extended from the coring tool 101 into the formation 105. The coring tool 101 may be braced in the borehole by one or

more support arms 111. An example of a commercially available coring tool is further described in U.S. Patent Nos. 4,714,119 and 5,667,025, both assigned to the assignee of the present invention.

[0011] FIG. 2 shows a perspective view of an existing coring device 201 taking a core sample 207 from a formation 203. A coring bit 205 is connected to the coring device 201, which may include a motor to extend the bit 205 and impart rotary motion to the coring bit 205. The coring bit 205 extends into the formation 203, and a core sample 207 is captured in the interior of the coring bit 205. It is noted that the coring device 201 would typically be disposed in a coring tool (e.g., 101 in FIG. 1) for use down-hole. The coring bit 205 would extend from the device 201 and tool (e.g., 101 in FIG. 1) and into the formation 203.

[0012] Rotary coring tools typically use a hollow cylindrical coring bit with a formation cutter at a distal end of the coring bit. The coring bit is rotated and forced against the wall of the bore hole. As the coring bit penetrates the formation, the hollow interior of the bit receives the core sample. A rotary coring bit is extended from the tool using a shaft of mechanical linkage. The shaft is typically connected to a

motor that imparts rotary motion to the coring bit and forces the bit against the formation wall. Rotary coring tools are generally braced against the opposite wall of the bore hole by a support arm. The cutting edge of the rotary coring bit is usually embedded with tungsten carbide, diamonds, or other hard materials for cutting into the formation.

[0013] FIG. 3 shows an example of a conventional rotary coring bit 301 that may be used with a sidewall coring tool, such as the coring tool 101 of Figure 1. A similar coring bit is disclosed in U.S. Patent No. 6,371,221, which is assigned to the assignee of the present invention. The coring bit 301 includes a shaft 303 that has a hollow interior 305. A formation cutting element 307 for drilling is located at one end of the shaft 303. As the coring bit 301 penetrates a formation (not shown) and a sample core (not shown) may be received in the hollow interior 305 of the bit 301. After a sample is received in the hollow interior 305, the core sample typically is broken from the formation by displacing or tilting the drill system. The coring bit 301 is then removed from the formation, with the core sample retained in the hollow interior 305 of the coring bit 301. Other known formation cutting elements for a rotary cor-

ing bit may be used. Examples of such formation cutting elements are described in copending U.S. Patent Application Serial No. 09/832,606, assigned to the assignee of the present invention.

[0014] While existing coring tools are useful, there is still a need for a coring tool that will more effectively ensure a good core sample can be retrieved for analysis.

SUMMARY OF INVENTION

[0015] In one or more embodiments, the invention relates to a sidewall coring tool that includes a tool body, a hollow coring shaft extendable from the tool body, a formation cutter disposed at a distal end of the hollow coring shaft, and a retention member segmented into a plurality of petals and disposed in the hollow coring shaft. In some embodiments, the plurality of petals comprises three petals.

[0016] In some embodiments, the invention relates to a method for taking a core sample that includes extending a coring bit into a formation, receiving the core sample in an internal sleeve having a retention member segmented into a plurality of petals proximate a distal end of the internal sleeve, and withdrawing the coring bit from the formation.

[0017] In some other embodiments, the invention related to a

sidewall coring tool that includes a tool body, a hollow coring shaft extendable from the tool body, a formation cutter disposed at a distal end of the hollow coring shaft, an internal sleeve disposed inside the hollow coring shaft, and at least one retention mechanism selected the group consisting of a piston and a check valve, wherein the piston is disposed in the internal sleeve and moveable with respect to the internal sleeve, and the check valve is disposed in the internal sleeve.

[0018] In some embodiments, the intention relates to a method for taking a core sample that includes extending a coring bit into a formation, receiving the core sample in an internal sleeve having a piston disposed therein such that the piston is moveable with respect to the internal sleeve, and withdrawing the coring bit from the formation.

[0019] In some embodiments, the invention relates to a sidewall coring tool that includes a tool body, a hollow coring shaft extendable from the tool body, a formation cutter disposed at a distal end of the hollow coring shaft, and an internal sleeve disposed inside the hollow coring shaft. The internal sleeve may include a bladder configured to apply radial pressure to a core sample when the bladder is selectively filled with a fluid.

[0020] In some embodiments, the invention relates to a sidewall coring tool that includes a tool body, a hollow coring shaft extendable from the tool body, a formation cutter disposed at a distal end of the hollow coring shaft, and an elastic retention member disposed proximate a distal end of coring tool and having an aperture at its center.

[0021] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0022] FIG. 1 is a cross-section of a wellbore with a prior art coring tool suspended in the wellbore.

[0023] FIG. 2 is a perspective view of a prior art coring device.

[0024] FIG. 3 is a perspective view of a prior art rotary coring bit.

[0025] FIG. 4A is a cross section of a coring bit in accordance with one embodiment of the invention.

[0026] FIG. 4B is a cross section of a coring bit in accordance with one embodiment of the invention.

[0027] FIG. 4C is a cross section of a coring bit in accordance with one embodiment of the invention.

[0028] FIG. 5A is a cross section of a coring bit with a retention device in accordance with one embodiment of the inven-

tion.

[0029] FIG. 5B is a cross section of a coring bit with a retention device in accordance with one embodiment of the invention.

[0030] FIG. 6A is a top view of a coring bit retention member in accordance with one embodiment of the invention.

[0031] FIG. 6B is a top view of a coring bit retention member in accordance with one embodiment of the invention.

[0032] FIG. 6C is a top view of a coring bit retention member in accordance with one embodiment of the invention.

[0033] FIG. 6D is a top view of a coring bit retention member in accordance with one embodiment of the invention.

[0034] FIG. 7A is a cross section of a coring bit retention member in accordance with one embodiment of the invention.

[0035] FIG. 7B is a cross section of a coring bit retention member in accordance with one embodiment of the invention.

[0036] FIG. 7C is a cross section of a coring bit retention member in accordance with one embodiment of the invention.

[0037] FIG. 7D is a cross section of a coring bit retention member in accordance with one embodiment of the invention.

[0038] FIG. 7E is a cross section of a coring bit retention member and internal sleeve in accordance with one embodiment of the invention.

- [0039] FIG. 8A is a cross section of a coring bit with a piston in accordance with one embodiment of the invention.
- [0040] FIG. 8B is a cross section of a coring bit with a piston in accordance with one embodiment of the invention.
- [0041] FIG. 9 is a cross section of a coring bit with a cushion in accordance with one embodiment of the invention.
- [0042] FIG. 10 is a cross section of a coring bit with a sample retention device in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

- [0043] In some embodiments, the invention relates to a coring bit with a retention member that retains a core sample in a coring bit. In other embodiments, the invention includes a piston or cushion that enables a core sample to be received and retained in a coring tool. In other embodiments, the invention relates to methods for retaining a core sample in a coring tool. The invention will now be described with reference to the attached drawings.
- [0044] FIG. 4A is a cross section of a coring bit 401 with a retention member 411 in accordance with one embodiment of the invention. FIG. 4A shows only the coring bit 401, but those having skill in the art will understand that the coring bit 401 forms part of a coring tool (not shown) that is

used to take core samples from a formation. By way of example, the coring bit may form part of a coring tool, such as the coring tool 101 in FIG. 1.

[0045] The coring bit 401 in FIG. 4A includes a hollow shaft 403 with a formation cutter 405 disposed at a distal end of the shaft 403. The formation cutter 405, or formation cutter, is formed of a material for drilling into the formation 402. The formation cutter 405 may be formed of a strong material that is coated with a super hard material, such as polycrystalline diamond or tungsten carbide. In other embodiments, the formation cutter 405 may include other devices for cutting through soft formation, such as brushes. The term "distal end" is used to describe the end of the coring bit 401 that first contacts the formation. The distal end is the end of the shaft 403 that is the farthest from the center of the coring tool (not shown) while a sample is being taken. It is the first part of the coring bit 401 to penetrate a formation.

[0046] As shown in FIG. 4A, a coring bit 401 may include an internal sleeve 407 that is disposed inside the hollow shaft 403. The internal sleeve 407 is for receiving a core sample (not shown in FIG. 4A) as it enters the coring bit 401. In some embodiments, the internal sleeve 407 is a "non-

rotating" internal sleeve. A non-rotating internal sleeve is an internal sleeve that is free to rotate independent of the hollow shaft 403. Thus, as the coring tool penetrates a formation 402, friction between the internal sleeve and the core sample (e.g., 410 in FIGS. 4B and 4C) prevents the internal sleeve from rotating with respect to the formation 402. In some other embodiments, a mechanical stop, such as a key (not shown) may prevent the rotation of the internal sleeve. This reduces the erosion of the core sample by eliminating friction between the core sample and the internal sleeve during the sampling process. Examples of coring sleeves are disclosed in copending US Patent Application Serial No. 10/248,475, assigned to the assignee of the present invention.

[0047] A retention member 411 is disposed at the distal end of the internal sleeve 407. The retention member 411, as will be seen, enables a core sample to enter the coring bit 401 and the internal sleeve 407, and it also retains the core sample 410 in the internal sleeve 407 once the core sample 410 has been received in the coring bit 401.

[0048] FIG. 4B shows a cross section of a coring bit 401 in the process of receiving a core sample 410. As the formation cutter 405 penetrates the formation 402, a core sample

410 enters the coring bit 401. As the core sample 410 enters the internal sleeve 407, it pushes the petals 411a, 411b of the retention member 411 out of the way so that the core sample 410 may enter the coring bit 401. As the petals 411a, 411b move, they apply a radially inward force to the core sample 410 that serves to guide the core sample 410 and hold it in place.

[0049] FIG. 4C shows a cross section of a coring bit 401 that has received a core sample 410 in the internal sleeve 407 disposed inside the hollow shaft 403 of the coring bit 401. The core sample 410 is retained in the coring bit 401 by the petals 411a, 411b of the retention member (411 in FIG. 4A) in at least two ways. First, the petals 411a, 411b press inward on the core sample 410 to stabilize it and hold it in place. Second, when the coring bit 401 retracts from the formation 402, the petals 411a, 411b will tend to close and grip the core sample 410. In hard rock, the additional friction between the core sample 410 and the petals 411a, 411b will act as a wedge gripper that retains the core sample 410 in the coring bit 401.

[0050] In soft rock, the petals 411a, 411b may completely close and trap the core sample 410 in the coring bit 401. This may be advantageous because of the tendency of uncon-

solidated or soft formations to fall out of the coring bit. Instead of losing $\frac{3}{4}$ inch (~1.9 cm) to 1 inch (~2.5 cm) of the core sample of an unconsolidated formation, the petals 411a, 411b may close to retain the core sample 410 in the coring bit 401. The only core sample 410 that is lost is that part of the core sample that extends past the petals 511a, 511b. In some embodiments, the petals are about $\frac{1}{4}$ inch (~0.6 cm) in length, and about $\frac{1}{4}$ inch of the core sample is lost in the closing of the petals. This assists in capturing and retaining core samples of a soft formation that can simply fall out of the coring bit when the sample is taken using a conventional coring bit.

[0051] The retention member 411 shown in FIGS. 4A, 4B, and 4C is preferably made of rubber, although it can be made of any material that is flexible and still has a memory. A material with a memory will "remember" its original position such that it will tend to move back to its original position whenever it is displaced. In some embodiments, material remains in the elastic deformation regime even when completely displaced by the core sample. Thus, when the petals of a retention member are pushed radially outward by a core sample, the petals are flexible enough to give way so that the core sample can easily enter the coring

bit, but they also tend to push radially inward toward their original position. This tendency to move back to the original position is what creates the radial pressure against the core sample that will guide it into the coring bit and retain it there while the coring bit is being withdrawn from the formation.

[0052] In some embodiments, a retention member may not be attached at a distal end of an internal sleeve. For example, FIG. 5A shows a coring bit 501 with an internal sleeve 507 disposed inside a hollow coring shaft 503. A formation cutter 505 is disposed at the distal end of the hollow coring shaft 503. The retention member 511 is located near the mid-point along the axial length of the internal sleeve 507. In this position, a retention member 511 provides guidance so that a core sample (not shown) will be maintained near the axial center of the internal sleeve 507, while still offering the ability to retain the core sample in the coring bit 501 when the bit is withdrawn from the formation (not shown). For example, in a hard formation, the retention member 511 may act as a wedge gripper that retains the core sample (not shown) in the coring bit 501.

[0053] FIG. 5B shows another embodiment of a coring bit with a retention member 521 in accordance with the invention.

The coring bit 521 includes a hollow coring shaft 523 with a formation cutter 525 at its distal end. A retention member 531 is held in the center opening of the formation cutter by a ring 533 in the formation cutter. In this position, the retention member 531 may enable a core sample (not shown) to enter the coring bit 521, and it may also retain the core sample in the coring bit 521 once the sample is received.

[0054] It is noted that a coring bit in accordance with the invention may have various combinations of the described features. For example, may include a retention member located as shown in FIG. 5A, but without an internal sleeve. In another example, a coring bit may include a ring (e.g., ring 533 in FIG. 5B) that is not disposed proximate the distal end of the coring bit. Those having ordinary skill in the art will be able to devise other embodiments of an coring bit that do not depart from the scope of the invention.

[0055] FIG. 6A shows an end view of a retention member 601 in accordance with one embodiment of the invention. The retention member 601 has three petals 602a, 602b, 602c that are cut from the center of the retention member 601 out to an outer petal circumference 605. In some embodi-

ments, the petal circumference 605 is substantially the same size as the inner diameter of the formation cutter (e.g., 505 in FIGS. 5A, 5B. and 5C). This enables the core sample to fit snugly through the retention member. In other embodiments, the petal circumference 605 may be larger than the inner diameter of the formation cutter (e.g., 505 in FIGS. 5A, 5B. and 5C).

[0056] The petals 602a, 602b, 602c shown in FIG. 6A are located adjacent to one another. That is, the edges of one petal, 602a for example, are adjacent to edges on the other petals, 602b, 602c, for example.

[0057] In some embodiments, a retention member 601 includes cuts or perforations 607. The cuts 607 provide additional flexibility for the petals 602a, 602b, 602c when the retention member 601 is constructed of a stiff material or when there are only a small number of petals making each petal stiff.

[0058] FIG. 6B shows an embodiment of a retention member 621 with petals 622a, 622b, 622c that are not adjacent to each other. In this embodiment, the petals 622a, 622b, 622c are separated from each other going back to the petal circumference 625.

[0059] FIG. 6C shows another embodiment of a retention mem-

ber 631 in accordance with the invention. The petals 637, 638, 639 overlap with each other. For example, petal 637 has edge 637a that overlaps edge 639b of petal 639. The other edge 637b of petal 637 is overlapped by edge 638a of petal 638. Similarly, petal 639 has edge 639a that overlaps edge 638b of petal 638.

[0060] FIG. 6D shows another embodiment of a retention member 641 in accordance with the invention. The retention member includes an aperture 646 at its center. The aperture 646 is created because the retention member 641 extended inwardly only to an aperture circumference 647. A core sample (not shown) may push its way through the aperture 646 by displacing the retention member 641. The elasticity of the retention member 641 will cause the retention member 641 to exert an inward force on the core sample when it is received.

[0061] FIG. 6D also shows some other optional features of a retention member. For example, a retention member 641 with an aperture 646 may not have any petals. A core sample may simply displace a solid retention member. In other embodiments, such as the one shown in FIG. 6D, the retention member 641 may include one or more petals 642a, 642b, 642c. The petals 642a, 642b, 642c may be

individual petals, or the petals 642a, 642b, 642c may be perforated with perforations 643 extending between the aperture circumference 647 to the petal circumference 645. When a core sample (not shown) is taken, the core sample will break the perforations 643, and the core sample may be received in the coring bit (not shown).

[0062] In fact, it is noted that the many of the above disclosed embodiments of a retention member may use radial perforations to segment the retention member into petals. This would enable the retention member to serve as a cover that will prevent contaminants from entering the coring bit before a sample is taken and the perforations are broken.

[0063] It is noted that radial perforations are distinguished from circumferential perforations that may be used to increase the flexibility of the retention member.

[0064] FIGS. 7A–7E show various embodiments of a retention member for use with a coring bit in accordance with the invention. FIG. 7A shows a retention member 711 with petals 711a, 711b that are tapered inwardly. The petals 711a, 711b have a petal circumference that is substantially the same as the inner diameter of the formation cutter 705. A core sample will snugly pass through the petals

711a, 711b of the retention member 711.

[0065] FIG. 7B shows another embodiment of a retention member 721 where the petals 721a, 721b are tapered outwardly. In this embodiment, when the petals 721a, 721b are displaced by a core sample (not shown), the pressure applied by the petals 721a, 721b will be slightly greater because they are displaced farther from their original position.

[0066] FIG. 7C shows another embodiment of a retention member 731 in accordance with the invention. The petals 731a, 731b of the retention member 731 are rounded and extruding into the internal sleeve 707. When a core sample (not shown) is received in the internal sleeve 707, the petals 731a, 731b will be displaced inwardly.

[0067] FIG. 7D shows another embodiment of a retention member 741 in accordance with the invention. The petals 741a, 741b of the retention member 741 are rounded and extruding outwardly from the internal sleeve 707. When a core sample (not shown) is received in the internal sleeve 707, the petals 741a, 741b will be displaced inwardly.

[0068] FIG. 7E shows an embodiment of a retention member 751 that is similar to that shown in FIG. 7B. In FIG. 7E, the internal sleeve 757 has a notch 753 that provides space for the petals 751a, 751b in their displaced position. The in-

ner diameter D2 of the internal sleeve 757 in the notch 753 is larger than the nominal diameter D1755 of the internal sleeve 757. In the embodiment shown, the nominal diameter D1755 of the internal sleeve 757 is substantially the same as the inner diameter of the formation cutter 705. As a core sample (not shown) passes into the internal sleeve 757, the petals 751a, 751b of the retention member 751 will be displaced into the notch 753. The petals 751a, 751b, when displaced into the notch 753, have substantially the same inner diameter as the nominal diameter D1755 of the internal sleeve 757. This enables the core sample 701 to fit snugly at all points along the axis of the internal sleeve 757, while still gaining the advantages of a retention member in accordance with embodiments of the invention.

[0069] The embodiment of an internal sleeve 757 that is shown in FIG. 7E may be used with various embodiments of a retention member. For example, an internal sleeve 757 with a notch 753 may be used with any of the embodiments of a retention member shown in FIGS. 7A-7E.

[0070] A retention member in accordance with any of the embodiments of the invention may be designed specifically for a single use, or it may be designed to capture and re-

tain multiple cores. For example, some coring bits are designed so that the core samples are stored in the internal sleeve. That is, the internal sleeve is moved from inside the coring bit into a storage area. In other embodiments, only the core sample is moved into a storage device, and the internal sleeve is used to capture another sample.

[0071] As will be understood by those having ordinary skill in the art, FIGS. 7A–7E show a cross section of particular embodiments of a coring bit and a retention member in accordance with the invention. As such, the figures show only two petals in each embodiment. This is simply a function of a cross section, and it is not intended to limit the invention. A retention member in accordance with the invention may have any number of petals. Optionally, the retention member may be uniform, solid, tapered, or have one or more apertures therethrough. Other configurations may be envisioned. The retention member may be adapted to tear and/or stretch as the core sample advances into the sleeve. Portions of the retention member that are stretched or torn may apply force to the core sample to grip the core sample. The retention member is preferably elastic so that it may retract to substantially its original configuration and close behind the core sample

thereby restricting portions of the core sample from exiting the coring sleeve.

[0072] FIG. 8A shows a cross section of a coring bit 800 with an internal sleeve 807 having a piston 802 in accordance with the invention. The piston 802 is axially moveable with respect to the internal sleeve 807. The piston 802 is initially positioned proximate the distal end of the internal sleeve 807. When a core sample is being collected from the formation 810, the core sample will displace the piston 802 with respect to the internal sleeve 807. The piston 802 may also include seals 812 or bearings to enable easier movement of the piston 802 within the internal sleeve 807.

[0073] In the embodiment shown, the internal sleeve 807 has a diameter that is substantially the same as the inner diameter of the formation cutter 805. In order to fit with the internal sleeve 807, the piston 802 has a diameter that is substantially the same as the inner diameter of the internal sleeve 807 so that the piston seals 812 are able to form a seal between the internal sleeve 807 and the piston 802.

[0074] FIG. 8B shows a cross section of the coring bit 800 with a core sample 801 received inside the coring bit 800. The

core sample 801 has displaced the piston 802 to a position proximate the proximal end of the internal sleeve 807. The piston 802 moves as the core sample 801 is received in the coring bit 800. Thus, the piston 802 provides support for the core sample 801. This may be advantageous in unconsolidated formations, where the formation core sample would fall apart as it came into the coring bit. The piston 802 may prevent the formation from falling apart.

[0075] Additionally, when the coring bit 800 is withdrawn from the formation 810, the piston 802 helps to hold the core sample in the internal sleeve 807. In some embodiments, the chamber 815 behind the piston 802 includes a check valve or other means (not shown) to allow air or fluid to be pushed out of the chamber 815, but that will not allow the return flow. Thus, a vacuum behind the piston 802 will prevent the piston 802 from moving on the outward direction.

[0076] In some embodiments, the chamber 815 behind the piston is completely vented. Nonetheless, the core sample 801 may not be able to move out of the internal sleeve 807 without also moving the piston 802. This may be caused by a vacuum created between the piston 802 and

the core sample 801. The friction between the piston 802 and the internal sleeve 807 will create additional resistance to the movement of the core sample 801, which will help retain the core sample 801 in the coring bit 800.

[0077] Further, in addition to a simple piston 802, the internal sleeve 807 may also include a ratchet device or a locking device. Such a device would prevent the piston from moving in the outward direction.

[0078] FIG. 9 shows a cross section of a coring bit 900 that includes a cushion for receiving and retaining the core sample 901 in the bit 900. A hollow outer shaft 903 penetrates a formation 910 using a formation cutter 905 disposed at the distal end of the shaft 903. A core sample 901 is received in an internal sleeve 917 that is disposed inside the hollow shaft 903.

[0079] The cavity (shown at 918) in the internal sleeve 917 behind the core sample 901 is filled with a fluid, such as water. The proximal end of the internal sleeve 917 includes a valve 921 for selectively permitting fluid to pass between the sleeve 917 and the rest of the tool. The valve 921 may be, for example, a check valve that enables the fluid to exit the cavity 918 as a core sample 901 moves into the internal sleeve 917. When the coring bit 900 is withdrawn

from the formation, the valve 921 may be used to prevent the reverse flow of fluid into the cavity 918, and a vacuum is created behind the core sample 901 that retains the core sample 901 in the coring bit 900.

[0080] In at least one embodiment, the check valve 921 in FIG. 9 may be combined with the coring bit 800 in FIGS. 8A and 8B. In such an embodiment, the piston (802 in FIGS. 8A and 8B) would force the fluid through the check valve (921 in FIG. 9). The check valve (921 in FIG. 9) would prevent the return flow of fluid and the vacuum behind the piston (802 in FIGS. 8A and 8B) and, thereby, retain the piston core sample in place.

[0081] FIG. 10 shows a cross section of a coring bit 1001 in accordance with another embodiment of the invention. A hollow shaft 1003 has a formation cutter 1005 at a distal end of the shaft 1003. A bladder 1007 is used as an internal sleeve in the coring bit 1001 in FIG. 10. The bladder 1007, when deflated, provides enough space to accept a core sample. The bladder 1007 may then be selectively inflated by filling it with fluid. The fluid may be stored hydraulic fluid, or it may be drilling mud that is pumped into the bladder. The type of fluid used is not intended to limit the invention.

[0082] When the bladder 1007 is filled, it will compress inwardly and exert a radial pressure on a core sample (not shown). The pressure will apply an overburden to the core sample that will both stabilize and retain the core sample.

[0083] Embodiments of the invention may present one or more of the following advantages. A coring bit with a retention member or other retention device in accordance with the invention will retain the core sample in the coring bit while the coring bit is being withdrawn from the formation. This will prevent the core sample from being damaged or lost during this process.

[0084] Advantageously, a coring bit may include a retention member that will close completely when capturing a sample in soft or unconsolidated formation. When the retention member closes, the core sample will be completely enclosed in the coring bit and protected against further damage and loss.

[0085] Advantageously, a coring bit that includes a non-rotating internal sleeve will not degrade the core sample through friction between the core sample and the internal sleeve and the retention member. The internal sleeve and the retention member will not rotate with respect to the formation and the core sample as it is being captured.

[0086] Advantageously, embodiments of the invention that include a piston in the internal sleeve provide additional guidance for a core sample as it is being received. The piston is displaced by the core sample, and once the sample is fully received, the piston creates a vacuum or void behind the core sample that retains the core sample in the internal sleeve as the coring bit is withdrawn from the formation.

[0087] Advantageously, embodiments of the invention that include a cushion provide steady guidance for the core sample as it enters the coring bit. Once received in the coring bit, the core sample is retained by a vacuum or void behind the core sample.

[0088] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.